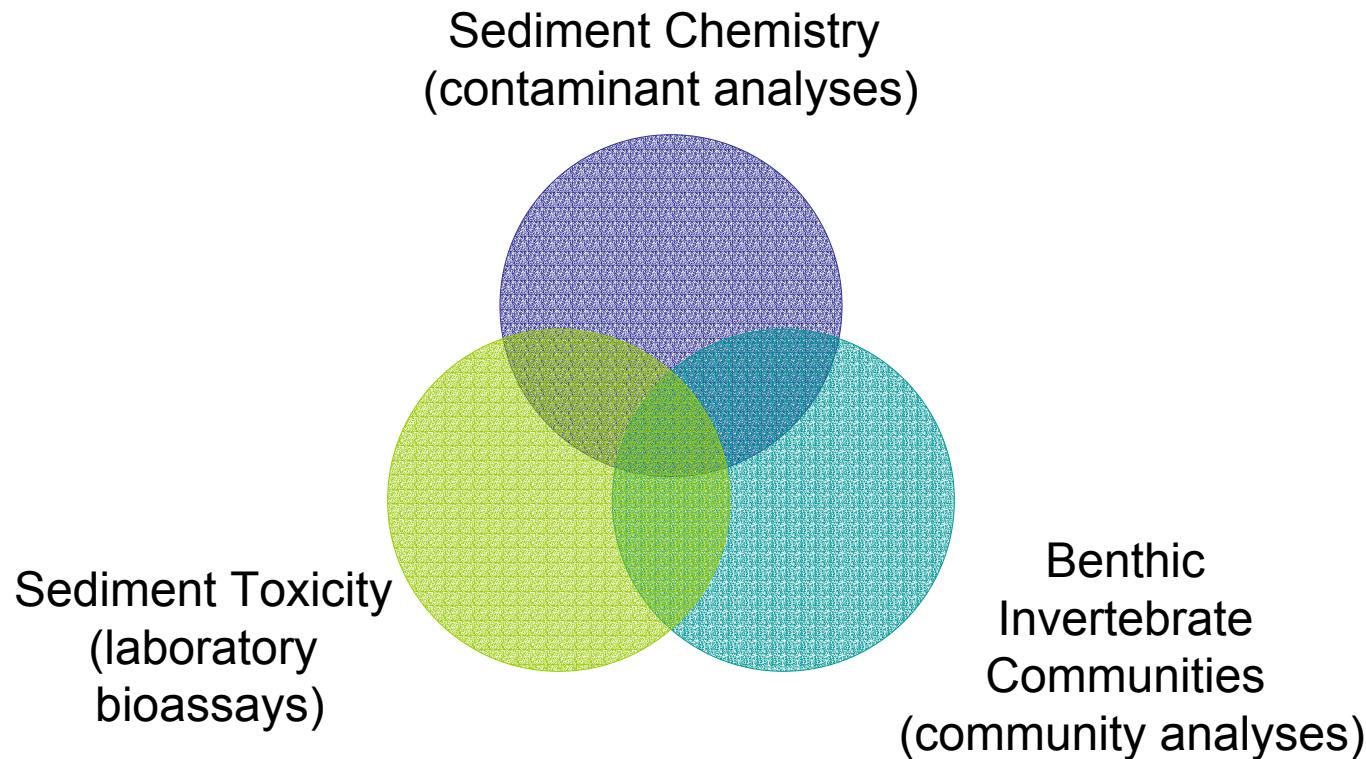


Preliminary Sediment Quality Triad (SQT) Assessment

The Sediment Quality Triad



SQT Potential Scenarios

Contamination	Toxicity	Alteration	Scenario
+	+	+	Strong evidence for impacts from chemical contamination
-	-	-	Strong evidence for no impacts from chemical contamination
+	-	-	Chemical contaminants are not toxic or bioavailable
-	+	-	Unmeasured chemical or physical conditions exist that are causing toxicity
-	-	+	Impacts are not caused by chemical contamination
+	+	-	Chemical contaminants may be causing toxicity
-	+	+	Unmeasured chemical or physical conditions exist that are causing toxicity and community impacts
+	-	+	Chemical contaminants are not bioavailable or community alterations are not due to toxic chemicals

Notes:

"+" = contamination, toxicity, and/or community alterations present

"-" = contamination, toxicity, and/or community alterations absent

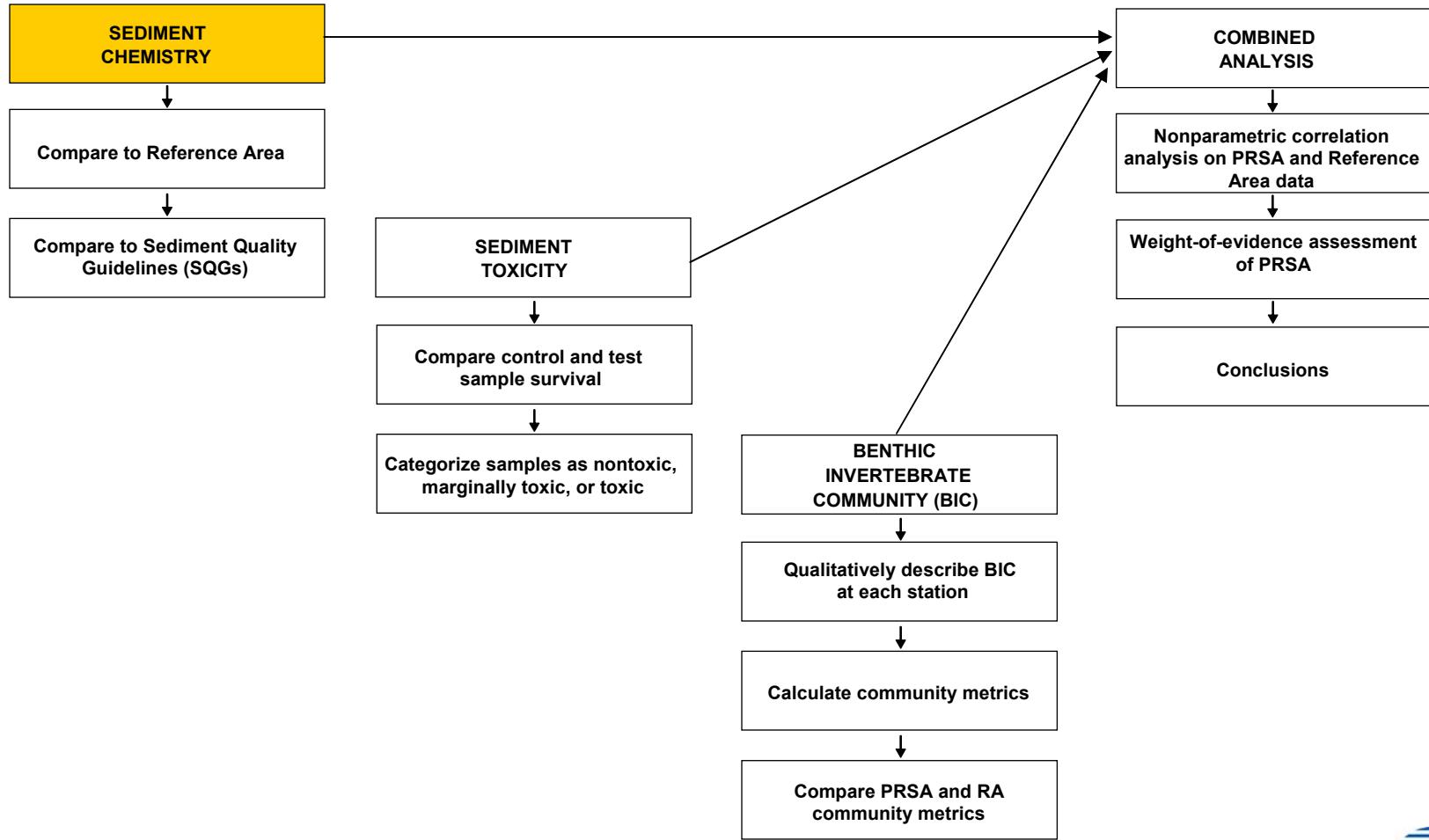
Objectives

- Compare sediment quality between the PRSA and Mullica River reference area
- Develop a qualitative, weight-of-evidence description for each PRSA station
- Rank and compare relative sediment quality among stations
- Identify which physico-chemical variables may influence sediment toxicity and/or benthic community alterations in PRSA

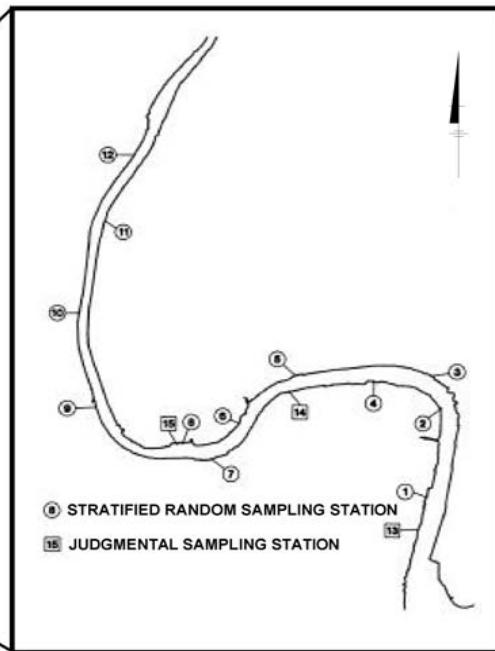
Methods

- Chemistry, toxicity, benthic community analyses documented in previous presentations
- Preliminary statistical analyses
 - Comparison of PRSA to Reference Area (RA)
 - Sediment quality guideline quotients (SQGQs)
 - Nonparametric Spearman correlations
- PRSA station classifications
- Weight-of-evidence assessment

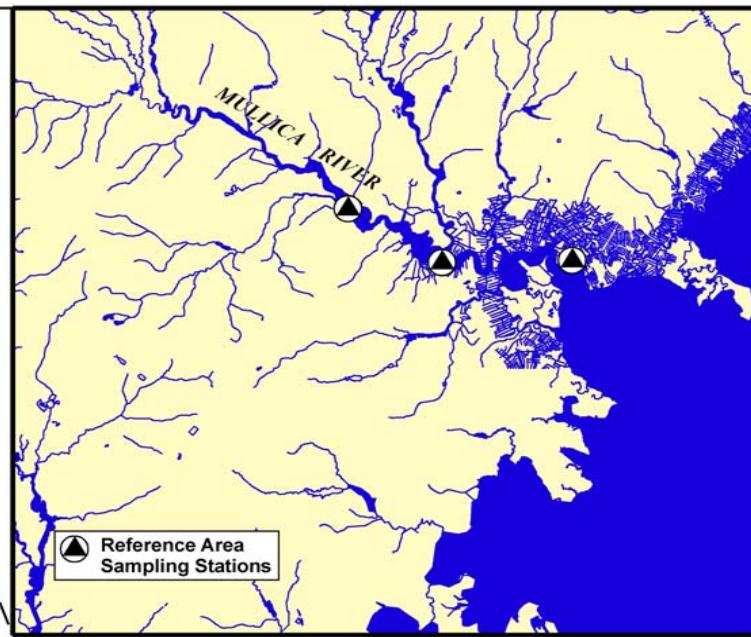
Steps in the SQT



PASSAIC RIVER
1999/2000 SAMPLING STATIONS



MULLICA RIVER
1999/2000 SAMPLING STATIONS



Sampling Stations in the PRSA and Mullica River Reference Area

PRSA Sediment Chemistry Data

- Described in detail in May 29, 2002 presentation
- Chemistry data from central sampling grid at each ESP station used in SQT – synoptically collected with toxicity and benthic invertebrate community data

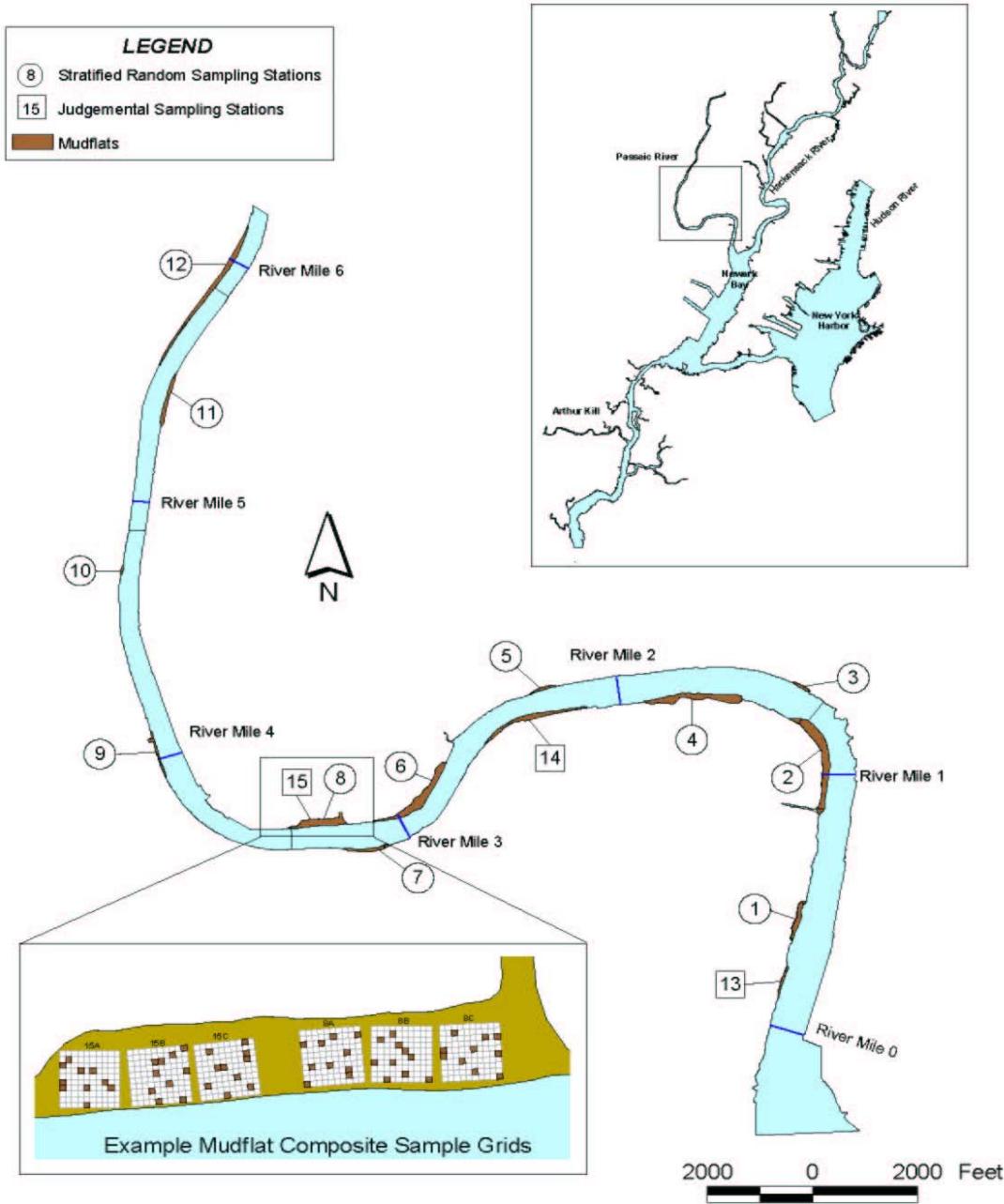


Figure 1. Passaic River Study Area and Sampling Stations

Chemicals Evaluated in the SQT

<i>Inorganic Chemicals</i>	<i>Miscellaneous</i>	<i>Polycyclic Aromatic Hydrocarbons (PAHs)</i>
Aluminum	Ammonia Nitrogen	High Molecular Weight PAHs (13) ^a [H-PAHs]
Antimony	Percent Fines	Low Molecular Weight PAHs (13) ^a [L-PAHs]
Arsenic	Total Organic Carbon	Total PAHs (13) ^a
Barium	Salinity	
Beryllium	pH	
Cadmium		<i>Semivolatile Compounds</i>
Calcium		1,4-Dichlorobenzene
Chromium	<i>Organotins</i>	2,4-Dichlorophenol
Cobalt	Dibutyltin	bis(2-Ethylhexyl)phthalate
Copper	Monobutyltin	Butyl benzyl phthalate
Iron	Tributyltin	Carbazole
Lead		Dibenzofuran
Magnesium	<i>Pesticides/Herbicides</i>	Dibenzothiophene
Manganese	Total DDT	Di-n-Butylphthalate
Mercury		Di-n-Octylphthalate
Nickel	<i>Polychlorinated Biphenyls (PCBs)</i>	N-Nitrosodiphenylamine
Potassium	Total PCBs - Sum of Homologue Groups	
Selenium		
Silver	<i>Polychlorinated Dibenzo-p-Dioxins and Furans (PCDD/Fs)</i>	
Sodium		
Thallium	WHO TEQ(Fish)	
Vanadium		
Zinc		

Notes:

^a Calculated using a limited congener set (13 PAHs) as described in Long et al., 1995.

Summary of Sediment Data for Central Sampling Grid of PRSA Stations

Analyte	Unit	N	Minimum	Min. Station(s)	Maximum	Max. Station(s)	Average ^a
Inorganic Chemicals							
Aluminum	mg/kg	15	7,150	3	22,300	13	16,177
Antimony	mg/kg	15	ND	3	1.6	10	0.84
Arsenic	mg/kg	15	5	3	15	4	11
Barium	mg/kg	15	59	3	341	13	168
Beryllium	mg/kg	15	0.50	3	1.2	13	0.88
Cadmium	mg/kg	15	1.5	3	6.7	4	4.2
Calcium	mg/kg	15	3,070	3	9,450	11	6,263
Chromium	mg/kg	15	59	3	182	13	137
Cobalt	mg/kg	15	5.4	3	14	4	11
Copper	mg/kg	15	79	3	273	7	191
Iron	mg/kg	15	16,100	3	40,600	13	32,067
Lead	mg/kg	15	101	3	334	11	257
Magnesium	mg/kg	15	3,300	3	9,480	13	6,779
Manganese	mg/kg	15	225	3	861	15	538
Mercury	mg/kg	15	0.91	3	5.8	11	3.1
Nickel	mg/kg	13	32	5	48	6	40
Potassium	mg/kg	10	1,130	3	4,930	13	2,736
Selenium	mg/kg	15	ND	1-3; 13	2.2	11	1.3
Silver	mg/kg	15	1.4	3	4.9	4	3.5
Sodium	mg/kg	15	880	15	9,440	1	4,019
Thallium	mg/kg	11	0.48	3	3.7	15	2.4
Vanadium	mg/kg	15	21	3	55	13	44
Zinc	mg/kg	13	346	2	641	11	541
Miscellaneous							
Ammonia Nitrogen	mg/kg	15	81	3	530	11	316
Percent Fines	%	15	30	3	90	14	73
Total Organic Carbon	mg/kg	15	9,300	3	46,700	8	33,913
Salinity	ppt	15	0.59	11	19	1	6.7
pH	pH Units	15	6.8	15	8.1	6	7.2

Note:

^a 1/2 detection limit used to calculate average if station value was a non-detect

ND = not detected.

Summary of Sediment Data for Central Sampling Grid of PRSA Stations (cont.)

Analyte	Unit	N	Minimum	Min. Station(s)	Maximum	Max. Station(s)	Average ^a
<i>Organotins</i>							
Monobutyltin	µg/kg	15	0.23	3	4.4	12	0.85
Dibutyltin	µg/kg	15	2.3	2	59	12	9.3
Tributyltin	µg/kg	15	ND	6,8	89	7	26
<i>Pesticides/Herbicides</i>							
Total DDT	µg/kg	15	ND	4,5,10,15	1,210	9	176
<i>Polychlorinated Biphenyls (PCBs)</i>							
Total PCBs - Homologue Groups	µg/kg	15	907	3	2,610	15	1,736
<i>ych</i>							
PCDD/F TEQ(Fish)	µg/kg	15	0.18	3	2.4	11	0.54
<i>ycy</i>							
LMW PAHs	µg/kg	15	2,770	3	9,020	11	5,839
HMW PAHs	µg/kg	15	10,900	3	39,200	11	23,333
Total PAHs	µg/kg	15	13,600	3	48,200	11	29,167
<i>mv</i>							
1,4-Dichlorobenzene	µg/kg	15	ND	6-9; 11,12	190	4	889
2,4-Dichlorophenol	µg/kg	15	ND	1-13;15	560	14	1,090
bis(2-Ethylhexyl)phthalate	µg/kg	15	6,400	3	33,000	11	13,333
Butyl benzyl phthalate	µg/kg	15	100	3	360,000	11	24,854
Carbazole	µg/kg	15	170	5	2,750	6	915
Di-n-Butylphthalate	µg/kg	15	ND	2; 4-10; 12-15	1,100	11	984
Di-n-Octylphthalate	µg/kg	15	ND	6-8; 11-13	980	9	1,180
Dibenzofuran	µg/kg	15	ND	6,7,8,12,14	640	11	776
Dibenzothiophene	µg/kg	15	65	3	294	11	193
N-Nitrosodiphenylamine	µg/kg	15	ND	4; 6-9; 11-14	180	15	958

Note:

^a 1/2 detection limit used to calculate average if station value was a non-detect

ND = not detected.

Summary of Sediment Data for Central Sampling Grid of Reference Area Stations

Analyte	Unit	N	Minimum	Min. Station(s)	Maximum	Max. Station(s)	Average ^a
Inorganic Chemicals							
Aluminum	mg/kg	3	18,300	21	23,400	22	21,167
Antimony	mg/kg	3	ND	21,23	1.4	22	0.87
Arsenic	mg/kg	3	15	22	33	21	22
Barium	mg/kg	3	56	21	63	22	60
Beryllium	mg/kg	3	1.1	23	1.5	21	1.3
Cadmium	mg/kg	3	0.83	23	2.4	21	1.4
Calcium	mg/kg	3	4,690	22	6,120	21	5,517
Chromium	mg/kg	3	64	21	74	23	70
Cobalt	mg/kg	3	8.9	21	10	23	9.7
Copper	mg/kg	3	28	21	37	23	32
Iron	mg/kg	3	41,400	23	61,600	21	48,600
Lead	mg/kg	3	46	22	56	21	50
Magnesium	mg/kg	3	9,630	21	11,400	23	10,443
Manganese	mg/kg	3	225	21	308	23	267
Mercury	mg/kg	3	0.30	22	0.39	23	0.33
Nickel	mg/kg	1	30	21	30	21	NA
Potassium	mg/kg	3	3,410	21	6,110	23	5,017
Selenium	mg/kg	3	ND	NA	ND	NA	NA
Silver	mg/kg	3	0.31	21	0.82	23	0.58
Sodium	mg/kg	3	9,460	21	18,500	23	12,987
Thallium	mg/kg	3	ND	21,22	1.7	23	1.01
Vanadium	mg/kg	3	62	21	70	22	66
Zinc	mg/kg	1	155	21	155	21	NA
Miscellaneous							
Ammonia Nitrogen	mg/kg	3	240	23	510	21	360
Percent Fines	%	3	74	21	88	22	82
Total Organic Carbon	mg/kg	3	28,800	23	66,200	21	42,600
Salinity	ppt	3	0.85	22	23	23	11
pH	pH Units	3	6.6	21	7.3	23	6.95

Note:

^a 1/2 detection limit used to calculate average if station value was a non-detect

NA = not applicable.

ND = not detected.

Summary of Sediment Data for Central Sampling Grid of Reference Area Stations (cont.)

Analyte	Unit	N	Minimum	Min. Station(s)	Maximum	Max. Station(s)	Average ^a
<i>Organotins</i>							
Monobutyltin	µg/kg	2	ND	NA	ND	NA	NA
Dibutyltin	µg/kg	2	ND	NA	ND	NA	NA
Tributyltin	µg/kg	2	ND	NA	ND	NA	NA
<i>Pesticides/Herbicides</i>							
Total DDT	µg/kg	3	9	23	26	21	16
<i>Polychlorinated Biphenyls (PCBs)</i>							
Total PCBs - Homologue Groups	µg/kg	3	32	21	45	23	38
<i>Polychlorinated Dibenzo-p-Dioxins and Furans (PCDD/Fs)</i>							
PCDD/F TEQ(Fish)	µg/kg	3	0.0080	23	0.0094	21	0.0086
<i>Polycyclic Aromatic Hydrocarbons</i>							
LMW PAHs	µg/kg	3	136	22	260	21	183
HMW PAHs	µg/kg	3	418	22	533	21	493
Total PAHs	µg/kg	3	554	22	793	21	676
<i>Semivolatile Compounds</i>							
1,4-Dichlorobenzene	µg/kg	3	ND	NA	ND	NA	NA
2,4-Dichlorophenol	µg/kg	3	ND	NA	ND	NA	NA
bis(2-Ethylhexyl)phthalate	µg/kg	3	ND	NA	ND	NA	NA
Butyl benzyl phthalate	µg/kg	3	ND	NA	ND	NA	NA
Carbazole	µg/kg	3	ND	NA	ND	NA	NA
Di-n-Butylphthalate	µg/kg	3	ND	NA	ND	NA	NA
Di-n-Octylphthalate	µg/kg	3	ND	NA	ND	NA	NA
Dibenzofuran	µg/kg	3	ND	NA	ND	NA	NA
Dibenzothiophene	µg/kg	3	4.1	22	6.5	21	5.1
N-Nitrosodiphenylamine	µg/kg	3	ND	NA	ND	NA	NA

Note:

^a 1/2 detection limit used to calculate average if station value was a non-detect

NA = not applicable.

ND = not detected.

Ratio-to-Reference (RTR) Calculations for PRSA

Chemical	PR13	PR1	PR2	PR3	PR4	PR14	PR5	PR6	PR7	PR8	PR15	PR9	PR10	PR11	PR12
Inorganic Chemicals															
Aluminum	1.1	0.9	0.6	0.3	0.9	0.7	0.7	0.8	0.8	0.9	0.7	0.5	0.7	0.8	0.8
Antimony	0.5	0.5	1.3	0.5	1.3	1.1	1.2	1.1	1.3	1.8	1.0	0.3	1.8	0.5	0.3
Arsenic	0.6	0.7	0.6	0.2	0.7	0.5	0.4	0.5	0.6	0.5	0.5	0.4	0.6	0.5	0.4
Barium	5.7	3.4	1.8	1.0	2.5	2.3	2.0	2.4	4.0	3.1	3.2	2.0	2.9	2.9	2.5
Beryllium	0.9	0.9	0.9	0.4	0.9	0.7	0.6	0.7	0.7	0.7	0.7	0.5	0.7	0.7	0.6
Cadmium	3.4	4.3	2.1	1.1	4.9	3.9	3.4	2.3	2.0	2.2	4.3	3.5	4.5	2.3	2.3
Calcium	1.3	1.1	0.7	0.6	1.3	1.1	0.9	1.3	1.0	1.3	1.3	0.9	1.5	1.7	1.1
Chromium	2.6	2.6	1.7	0.8	2.6	2.2	1.7	2.0	1.8	2.0	1.8	1.8	2.1	1.9	1.6
Cobalt	1.4	1.4	1.1	0.6	1.4	1.1	1.0	1.3	1.2	1.3	1.2	0.9	1.2	1.2	1.0
Copper	7.1	6.9	4.7	2.5	7.1	6.3	4.9	6.6	8.7	6.5	6.2	5.3	6.5	6.3	5.5
Iron	0.8	0.8	0.5	0.3	0.8	0.7	0.6	0.7	0.6	0.7	0.7	0.6	0.7	0.7	0.6
Lead	5.3	5.4	3.6	2.0	5.3	4.7	4.0	5.5	6.4	6.4	5.5	5.1	5.9	6.7	5.3
Magnesium	0.9	0.9	0.5	0.3	0.9	0.7	0.6	0.7	0.6	0.6	0.6	0.5	0.7	0.7	0.5
Manganese	2.3	1.9	1.1	0.8	1.9	2.2	1.6	1.8	1.5	2.6	3.2	1.8	2.5	2.7	2.2
Mercury	9.3	9.6	9.9	2.7	10.2	9.3	6.6	8.4	14.7	9.6	7.2	8.1	8.1	17.4	6.6
Nickel	R	1.5	1.3	R	1.5	1.3	1.1	1.6	1.4	1.5	1.3	1.2	1.4	1.5	1.2
Potassium	1.0	0.8	0.5	0.2	0.8	0.5	0.6	R	R	R	0.3	0.3	0.5	R	R
Selenium	0.6	0.8	0.6	0.3	2.4	1.7	1.7	3.1	2.4	2.8	1.8	2.0	2.1	3.1	2.7
Silver	7.8	7.6	3.8	2.4	8.5	6.9	5.4	5.9	6.6	6.4	6.4	5.0	7.5	5.7	6.2
Sodium	0.7	0.7	0.3	0.2	0.5	0.4	0.3	0.4	0.2	0.2	0.1	0.2	0.2	0.1	0.1
Thallium	1.8	R	R	0.5	2.7	R	3.0	2.3	1.5	2.1	3.7	R	3.6	2.7	2.2
Vanadium	0.8	0.8	0.7	0.3	0.8	0.6	0.6	0.7	0.7	0.7	0.6	0.5	0.6	0.8	0.6
Zinc	R	3.8	2.2	R	3.8	3.3	2.7	3.7	3.8	3.7	3.6	3.4	3.8	4.1	3.4
Miscellaneous															
Ammonia Nitrogen	0.6	0.9	0.5	0.2	0.7	1.2	0.8	1.4	0.5	0.7	1.3	0.7	0.9	1.5	1.3
Total Organic Carbon	0.9	0.8	0.4	0.2	0.9	0.8	0.6	0.9	0.8	1.1	1.0	0.9	0.9	0.9	0.8
Percent Fines	1.1	1.0	0.9	0.4	1.0	1.1	1.0	0.9	0.7	0.9	1.0	0.9	1.0	0.8	0.9
pH	1.0	1.1	1.1	1.0	1.1	1.0	1.1	1.2	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Salinity	1.1	1.2	0.9	0.9	0.8	0.8	0.5	0.4	0.4	0.6	0.4	0.6	0.3	0.2	0.2

Notes:

Shading indicates a ratio greater than 1.0, includes ND values.

ND - not detected in the Reference Area

R - result value for this chemical was rejected



Ratio-to-Reference (RTR) Calculations for PRSA (cont.)

Chemical	PR13	PR1	PR2	PR3	PR4	PR14	PR5	PR6	PR7	PR8	PR15	PR9	PR10	PR11	PR12
Organotins															
Dibutyltin	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Monobutyltin	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tributyltin	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Pesticides/Herbicides															
Total DDT	4.8	9.3	6.9	2.8	2.5	11	1.4	3.4	20	7.5	2.1	75	2.4	8.3	6.6
PCDD/Fs															
PCDD/F TEQ	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PCBs															
Total PCBs - Homologue Groups	55	46	32	24	51	46	44	44	49	35	69	32	58	47	55
PAHs															
HMW PAHs	44	32	42	22	45	40	60	51	47	49	52	49	36	80	62
LMW PAHs	34	23	26	15	29	29	35	40	27	37	40	30	25	49	37
Total PAHs	42	30	38	20	40	37	53	48	42	46	49	44	33	71	55
Semivolatile Compounds															
1,4-Dichlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,4-Dichlorophenol	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
bis(2-Ethylhexyl)phthalate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Butyl benzyl phthalate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Carbazole	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibenzofuran	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibenzothiophene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Di-n-Butylphthalate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Di-n-Octylphthalate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
N-Nitrosodiphenylamine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Notes:

Shading indicates a ratio greater than 1.0, includes ND values.

ND - not detected in the Reference Area

R - result value for this chemical was rejected



Sediment Quality Guideline Quotients (SQGQ)

- Average concentration of individual chemicals divided by respective SQG
- Average of these ratios calculated for each station to give SQGQ
- Sediments can be classified based on average SQGQ

Ratio of Chemical Concentration to Relevant Sediment Quality Guidelines (SQGs)

	MR23	MR22	MR21	PR13	PR1	PR2	PR3	PR4	PR14	PR5	PR6	PR7	PR8	PR15	PR9	PR10	PR11	PR12
Inorganic Chemicals																		
Antimony	0.018	0.056	0.030	0.016	0.016	0.044	0.018	0.044	0.038	0.040	0.038	0.044	0.064	0.036	0.012	0.064	0.016	0.012
Arsenic	0.24	0.22	0.47	0.18	0.20	0.19	0.071	0.21	0.16	0.13	0.15	0.196	0.15	0.15	0.13	0.17	0.15	0.13
Cadmium	0.086	0.091	0.25	0.49	0.61	0.30	0.16	0.698	0.55	0.48	0.32	0.28	0.31	0.61	0.50	0.64	0.32	0.32
Chromium	0.199	0.19	0.17	0.49	0.48	0.33	0.16	0.49	0.42	0.33	0.39	0.35	0.38	0.35	0.34	0.40	0.36	0.31
Copper	0.14	0.11	0.10	0.83	0.81	0.54	0.29	0.83	0.74	0.57	0.77	1.0	0.76	0.72	0.62	0.76	0.74	0.64
Lead	0.22	0.21	0.26	1.2	1.2	0.83	0.46	1.2	1.1	0.92	1.3	1.5	1.5	1.3	1.2	1.4	1.5	1.2
Manganese	0.18	0.16	0.13	0.37	0.31	0.18	0.13	0.30	0.35	0.25	0.29	0.24	0.41	0.51	0.29	0.40	0.43	0.35
Mercury	0.55	0.42	0.44	4.4	4.5	4.6	1.3	4.8	4.4	3.1	3.9	6.9	4.5	3.4	3.8	3.8	8.2	3.1
Nickel	R	R	0.57	R	0.89	0.74	R	0.88	0.73	0.63	0.93	0.79	0.85	0.73	0.67	0.78	0.86	0.66
Silver	0.22	0.16	0.084	1.2	1.2	0.59	0.38	1.3	1.10	0.84	0.92	1.0	1.00	1.0	0.78	1.2	0.89	0.97
Zinc	R	R	0.38	R	1.4	0.8	R	1.5	1.3	1.0	1.4	1.5	1.4	1.4	1.3	1.4	1.6	1.3
Pesticides																		
Total DDT	0.20	0.28	0.57	1.7	3.3	2.4	0.98	0.88	3.8	0.49	1.2	7.0	2.6	0.74	26	0.84	2.9	2.3
PCBs																		
Total PCBs - Homologue Groups	0.25	0.20	0.18	12	10	7	5	11	10	9	9	10	7.3	15	6.7	12	10	12
PAHs																		
LMW PAHs	0.049	0.043	0.082	2.0	1.4	1.5	0.877	1.7	1.7	2.0	2.3	1.6	2.2	2.3	1.7	1.5	2.9	2.1
HMW PAHs	0.055	0.044	0.056	2.3	1.7	2.2	1.1	2.3	2.0	3.1	2.6	2.4	2.5	2.7	2.5	1.9	4.1	3.2
Total PAHs	0.015	0.012	0.018	0.63	0.45	0.57	0.30	0.61	0.56	0.81	0.72	0.63	0.69	0.73	0.66	0.50	1.1	0.83
PCDD/Fs																		
2,3,7,8-TCDD	ND	ND	ND	0.010	0.010	0.022	0.006	0.014	0.020	0.013	0.014	0.026	0.011	0.012	0.014	0.012	0.092	0.011
Semivolatile Compounds																		
bis (2-Ethylhexyl)phthalate	ND	ND	ND	5.7	5.3	2.9	2.4	5.7	4.2	3.8	3.8	5.3	4.9	5.3	3.7	4.5	12	5.7

Notes:

Dieldrin and chlordane were not detected in the PRSA and Reference Area middle sampling grid in the Fall 1999 ESP sampling event.

Shading indicates ratio of greater than 1.0.

R - Rejected sample value

ND - Not detected



Sediment Quality Guideline Quotients (SQGQ)

SQGQ	Calculational Method
ER-M Quotient (PAH categories)	Calculated using ER-Ms for the following chemicals: As, Cd, Cr, Cu, Pb, Hg, H-PAH, L-PAH, Total PAHs, Total PCBs (homologue groups), Ag, Total DDT, and Zn. PAH categories calculated using the method of Long et al. (1995) with only 13 PAHs as listed in the individual PAHs ER-MQ below.
ER-M Quotient (PAH individual)	Calculated using ER-Ms for the following chemicals: As, Cd, Cr, Cu, Pb, Hg, 2-Methylnaphthalene, Diben[a,h]anthracene, Acenaphthene, Acenaphthylene, Anthracene, Benz[a]anthracene, Benzo[a]pyrene, Chrysene, Fluoranthene, Fluorene, Naphthalene, Phenanthrene, Pyrene, Total PCBs (homologue groups), Ag, Total DDT, and Zn.
SQGQ ER-M + Mn	Calculated using ER-Ms for the following chemicals: As, Cd, Cr, Cu, Pb, Hg, H-PAH, L-PAH, Total PAHs, Total PCBs (homologue groups), Ag, Total DDT, and Zn plus a benchmark value for Mn. PAH categories calculated using the method of Long et al. (1995) with only 13 PAHs as listed in the individual PAHs ER-MQ above.
SQGQ ER-M + BEP	Calculated using ER-Ms for the following chemicals: As, Cd, Cr, Cu, Pb, Hg, H-PAH, L-PAH, Total PAHs, Total PCBs (homologue groups), Ag, Total DDT, and Zn plus a benchmark value for bis(2-ethylhexyl)phthalate. PAH categories calculated using the method of Long et al. (1995) with only 13 PAHs as listed in the individual PAHs ER-MQ above.
SQGQ ER-M + PCDD/F TEQ	Calculated using ER-Ms for the following chemicals: As, Cd, Cr, Cu, Pb, Hg, H-PAH, L-PAH, Total PAHs, Total PCBs (homologue groups), Ag, Total DDT, and Zn plus a benchmark value for PCDD/F TEQ. PAH categories calculated using the method of Long et al. (1995) with only 13 PAHs as listed in the individual PAHs ER-MQ above.
SQGQ All benchmarks	Calculated using ER-Ms for the following chemicals: As, Cd, Cr, Cu, Pb, Hg, H-PAH, L-PAH, Total PAHs, Total PCBs (homologue groups), Ag, Total DDT, and Zn plus benchmark values for Mn, and PCDD/F TEQ. PAH categories calculated using the method of Long et al. (1995) with only 13 PAHs as listed in the individual PAHs ER-MQ above.

SQGQs for the PRSA and RA

Station	ER-M Quotient (PAH categories)	ER-M Quotient (PAH individual)	SQGQ ER- M + Mn	SQGQ ER- M + BEP	SQGQ ER-M + PCDD/F TEQ	SQGQ All Benchmarks
PRSA						
1	1.9	1.5	1.8	2.2	1.8	1.9
2	1.6	1.4	1.5	1.6	1.5	1.5
3	0.86	0.79	0.81	1.0	0.80	0.86
4	1.9	1.6	1.8	2.2	1.8	2.0
5	1.7	1.6	1.6	1.8	1.5	1.6
6	1.8	1.6	1.7	1.9	1.7	1.7
7	2.5	1.9	2.3	2.7	2.3	2.4
8	1.8	1.5	1.7	2.0	1.7	1.8
9	3.3	2.5	3.1	3.4	3.1	3.0
10	1.9	1.5	1.8	2.1	1.8	1.9
11	2.5	2.2	2.3	3.1	2.3	2.8
12	2.0	1.8	1.9	2.3	1.9	2.0
13	2.1	1.8	1.9	2.3	1.9	2.1
14	2.0	1.6	1.9	2.1	1.8	1.9
15	2.1	1.8	2.0	2.3	2.0	2.1
Reference Area						
21	0.22	0.15	0.22	0.23	0.21	0.21
22	0.15	0.10	0.15	0.16	0.14	0.15
23	0.19	0.12	0.19	0.19	0.17	0.18

Classification System for PRSA and Reference Area Sediments based on SQGs/SQGQs

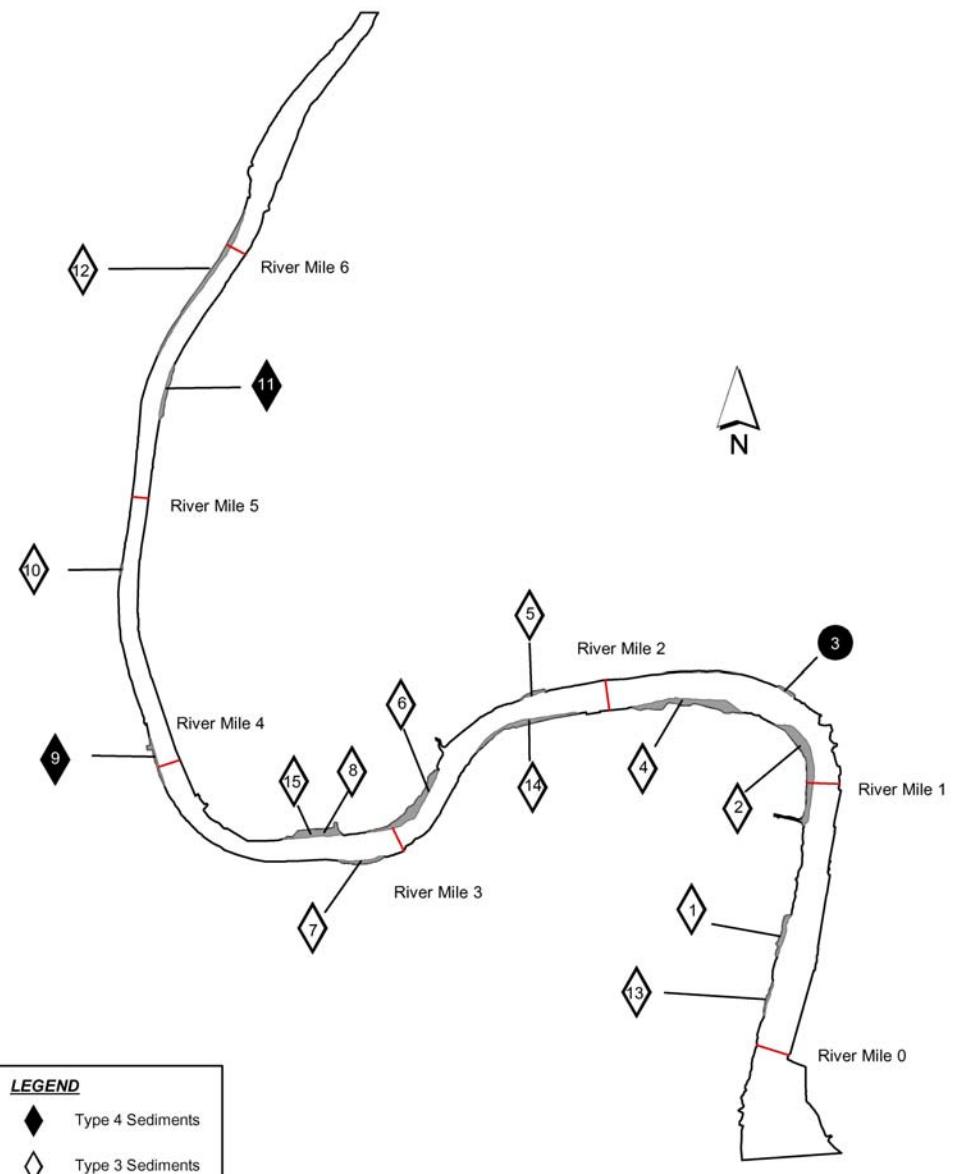
Sediment Type	Number of SQGs Exceeded	Average SQGQ Value
1	0	≤ 0.50
2	1-4	0.51-1.0
3	5-9	1.1-2.4
4	≥ 10	≥ 2.41

Notes:

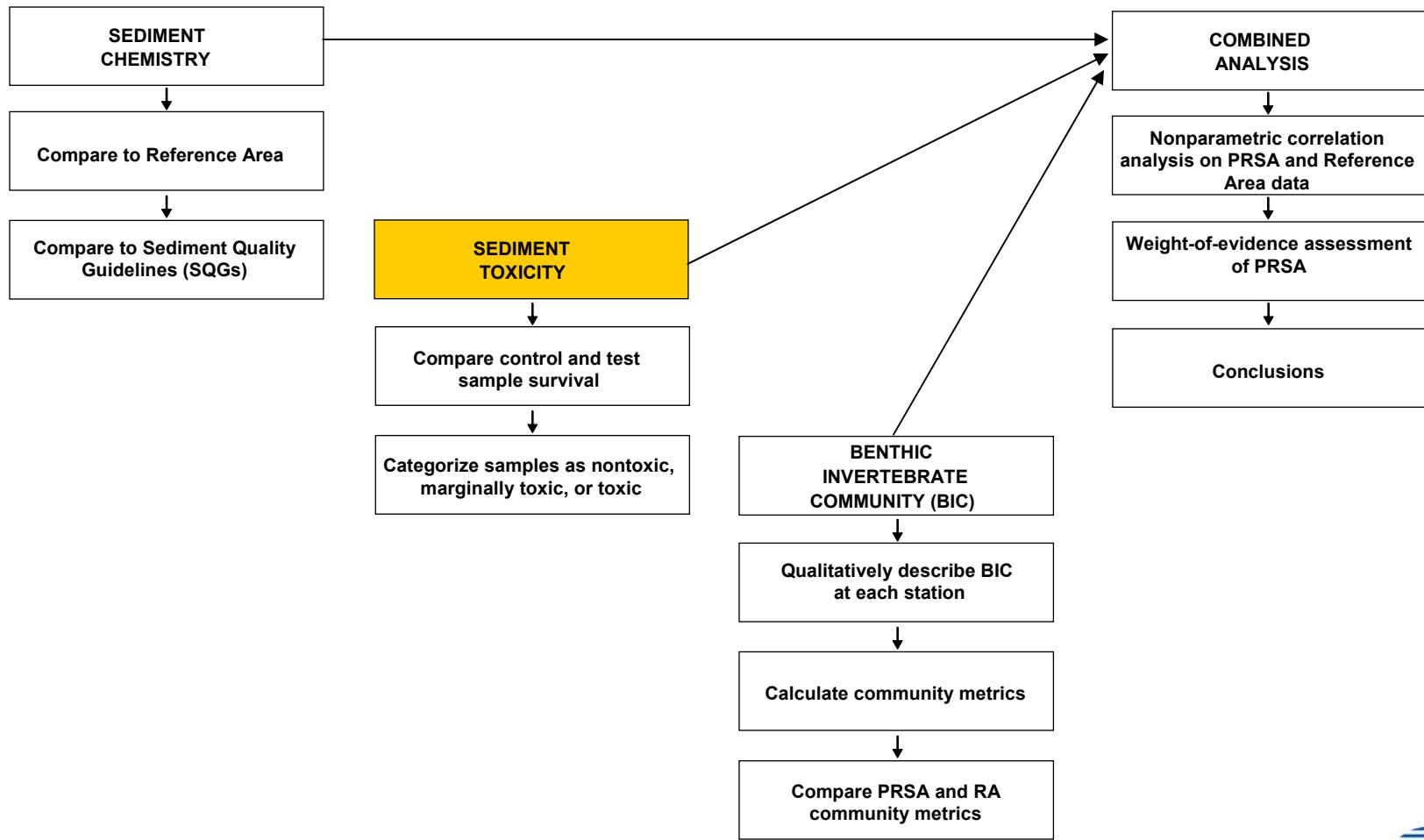
PRSA-specific classification system.

Reference Area stations contain Type 1 sediments.

SQGQ Classification in the PRSA



Steps in the SQT



PRSA Sediment Toxicity Data

- Described in detail in May 29, 2002 presentation
- Sediment for laboratory toxicity testing collected from central sampling grid at each ESP station

Sediment Sample Toxicity

A sample is considered:

- | | | |
|------------------|----|---|
| Nontoxic | if | mean survival was not significantly different ($p > 0.05$) from negative controls |
| Marginally toxic | if | mean survival was significantly lower than in negative controls ($p < 0.05$) but exceeded 80% of average survival in controls (amphipods) or exceeded 64% of average survival in controls (polychaetes) |
| Highly toxic | if | mean survival was significantly lower than in negative controls ($p < 0.05$) and < 80% of average survival in controls (amphipods) or < 64% of average survival in controls (polychaetes) |

Source: Long et al., 2000

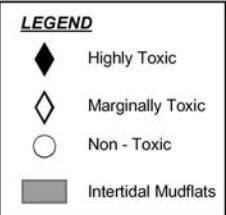
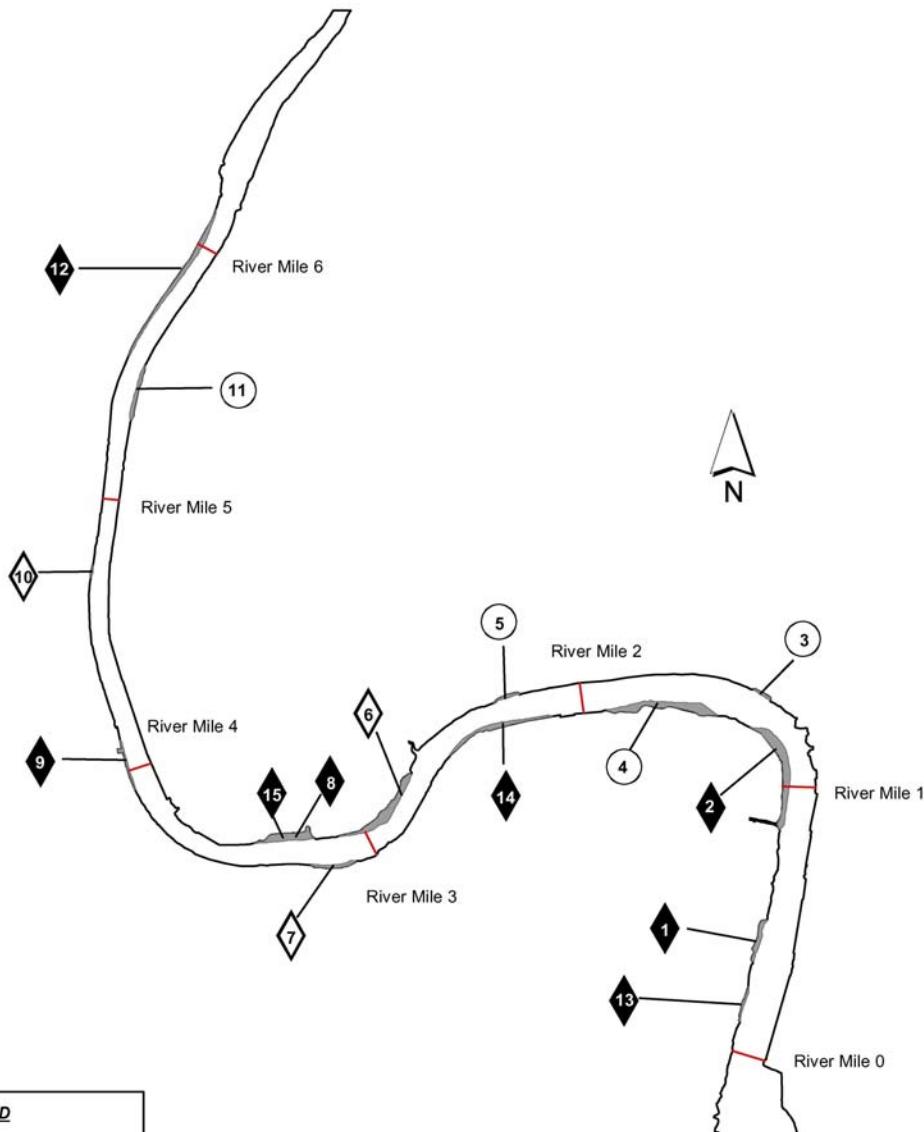
1999 PRSA Sediment Toxicity Testing Results

Station PRSA	Average Percent Survival (Amphipod)	Toxicity Category (Amphipod Survival)	Average Percent Survival (Polychaete)	Toxicity Category (Polychaete Survival)
1	70	Highly toxic	100	Nontoxic
2	68	Highly toxic	100	Nontoxic
3	83	Nontoxic	100	Nontoxic
4	85	Nontoxic	100	Nontoxic
5	79	Nontoxic	96	Nontoxic
6	72	M marginally toxic	100	Nontoxic
7	75	M marginally toxic	96	Nontoxic
8	43	Highly toxic	100	Nontoxic
9	46	Highly toxic	92	Nontoxic
10	75	M marginally toxic	100	Nontoxic
11	78	Nontoxic	92	Nontoxic
12	46	Highly toxic	84	M marginally Toxic
13	70	Highly toxic	92	Nontoxic
14	46	Highly toxic	100	Nontoxic
15	68	Highly toxic	96	Nontoxic
Reference Area				
21	95	Nontoxic	100	Nontoxic
22	92	Nontoxic	100	Nontoxic
23	92	Nontoxic	96	Nontoxic
Laboratory Controls				
1	89		100	
2	89		96	

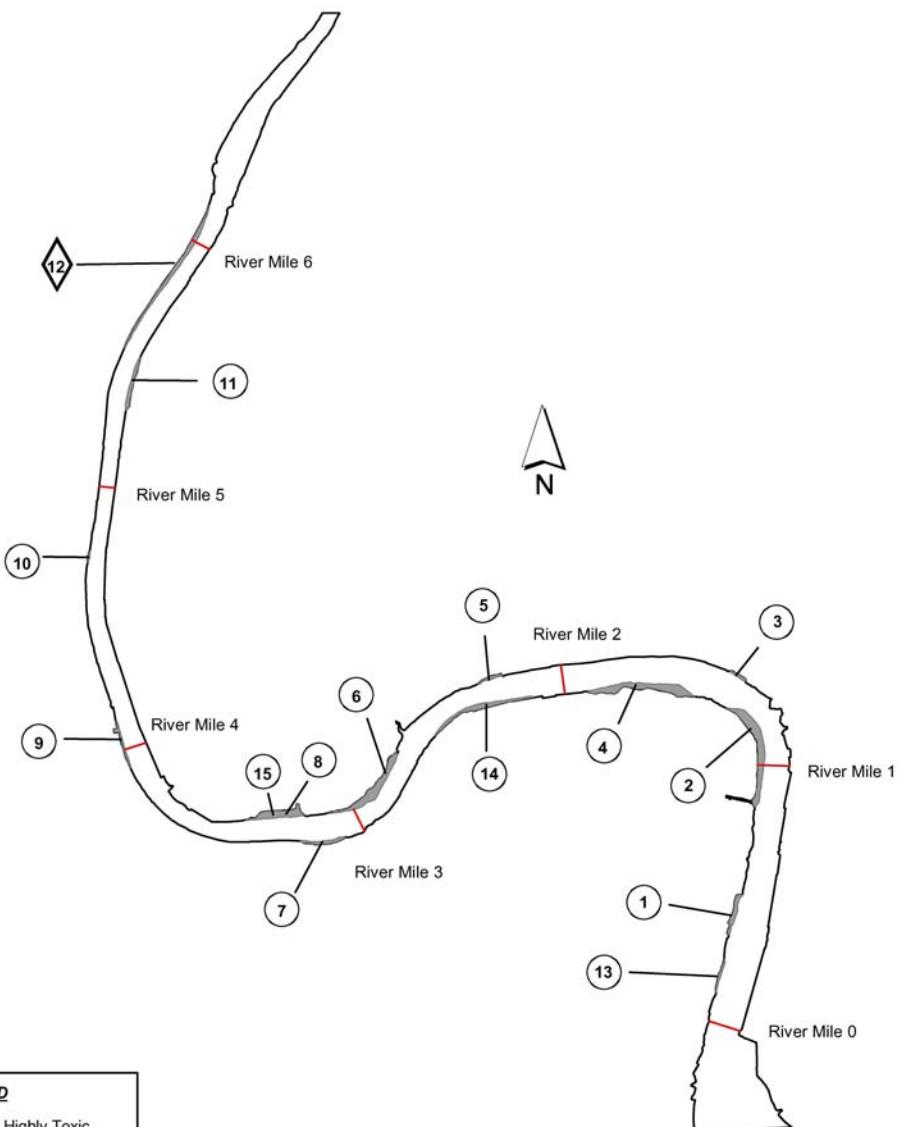
Note:

Data was arcsine square root transformed, which made the data meet ANOVA assumptions then a one-tail t-test with equal variance was performed to see which stations were significantly different from the negative controls.

1999 PRSA Amphipod Sediment Toxicity Classifications



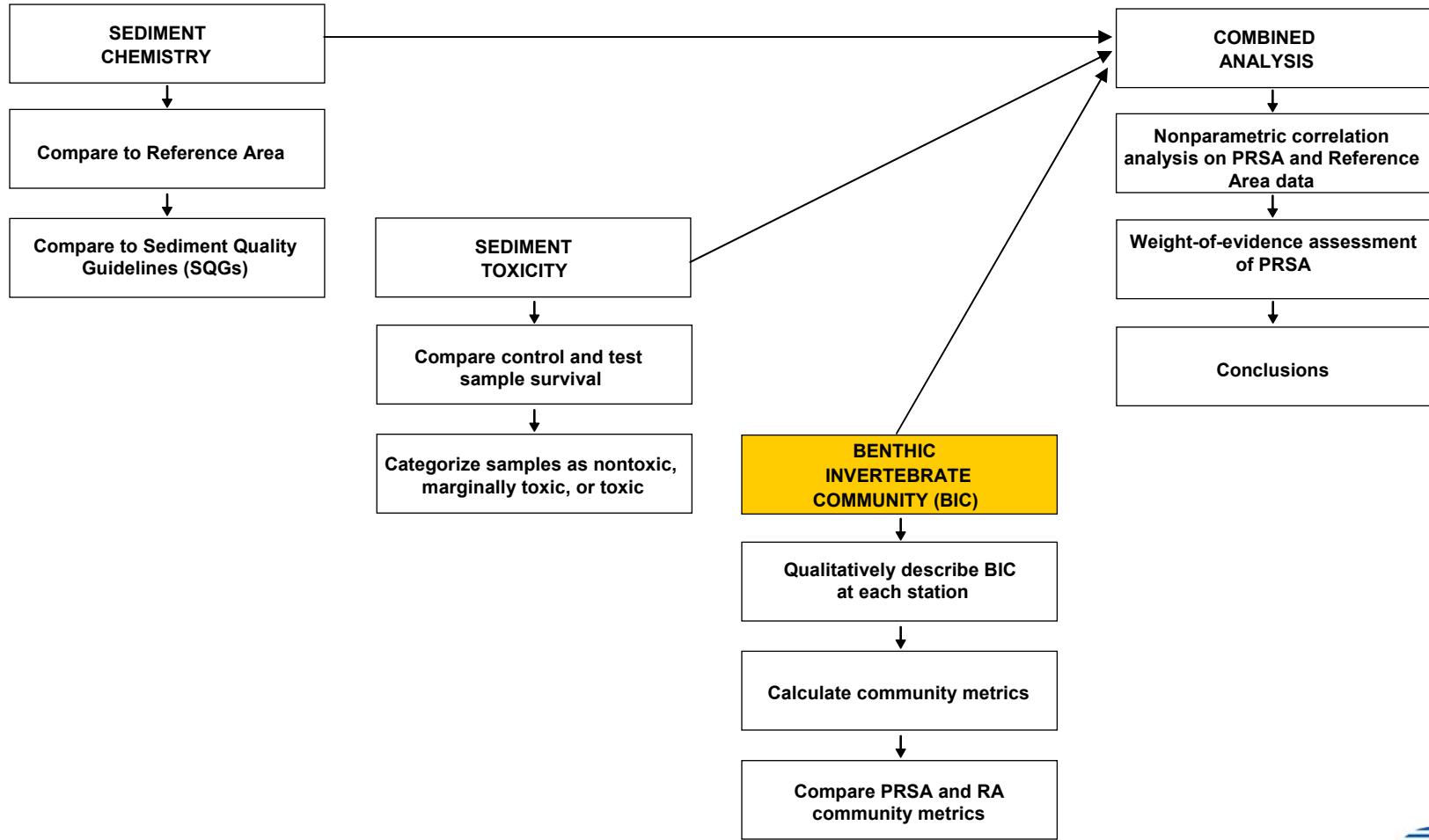
1999 PRSA Polychaete Sediment Toxicity Classifications



LEGEND

- ◆ Highly Toxic
- ◇ Marginally Toxic
- Non - Toxic
- Intertidal Mudflats

Steps in the SQT



PRSA Benthic Invertebrate Community Data

- Described in detail in benthic invertebrate community presentation
- Sediment samples for benthic invertebrate community analysis collected from central sampling grid at each station
- Community structure and composition metrics used to classify PRSA stations relative to RA

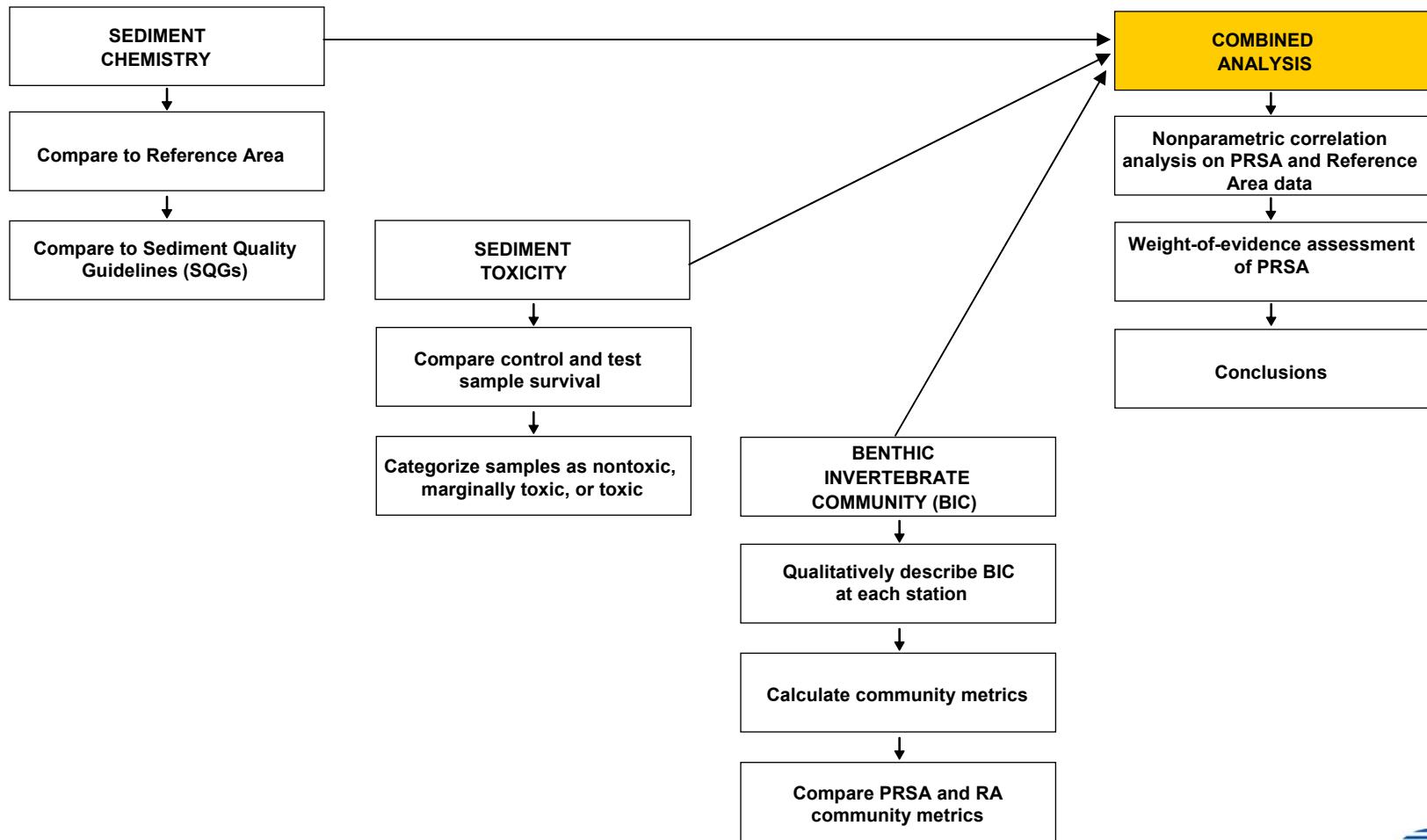
Qualitative Ranks for Each PRSA Station Compared to Reference Area

Metric	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
No. of Individuals ¹	poor	good	poor	poor	good	good	poor								
No. of Taxa	good	poor	good	poor	good	poor	good								
Abundance of Crustacea	poor	poor	poor												
Abundance of Tollerant Taxa ¹	poor	good	poor	good	good	good	poor	poor	poor						
Pielou's Evenness	poor	good	good	poor	good	good	good	good	good	poor	good	good	excellent	good	good
Shannon's H'	poor	poor	good	poor	poor	good	poor	good	poor	poor	poor	poor	excellent	poor	poor
Virginia IBI	poor	poor	good	poor	good	good	good	good	poor	poor	poor	poor	good	poor	poor
Brillouin's H	poor	poor	good	poor	poor	good	poor	good	poor	poor	poor	poor	excellent	poor	poor
Swartz Dominance Index	good	excellent	good	good											

Note:

¹ For the number of individuals and abundance of tolerant taxa metrics, the following ranks were assigned to each PRSA and Reference Area comparison: 1) above reference range = poor; b) within reference range = good; c) below reference range = excellent. For the remaining metrics, the following ranks were assigned for each PRSA/Reference Area comparison: a) above reference area = excellent; b) within reference area = good; c) below reference area = poor

Steps in the SQT



Nonparametric Spearman Rank Order Correlations

- Statistical analysis method used by NOAA National Status & Trends Program
- With a large number of variables, a Bonferroni correction must be applied to the alpha level ($\alpha = 0.05$) to reduce Type 1 error (chance of false positive result)
- Bonferroni correction =
$$\frac{\text{alpha level}}{\# \text{ of variables}} = \frac{0.05}{47} = 0.001$$
- A p-value ≤ 0.001 must be used for a correlation to be statistically significant

Nonparametric Correlations Between Sediment Chemistry, Toxicity, and Benthic Invertebrate Community Metrics

Analyte	N	Amphipod Survival	Number of Organisms	Number of Taxa	Shannon-Wiener H'	Pielou's Evenness J	Brillouin Diversity (H)	Virginian Province Biotic Index	Swartz's Dominance Index	Percent Crustacea	Percent Pollution-Tolerant Organisms
Inorganic Chemicals											
Aluminum	18	0.347	-0.265	0.241	0.263	-0.018	0.262	0.447	0.170	0.603	-0.395
Antimony	18	0.138	-0.285	0.108	-0.229	-0.542	-0.243	0.355	-0.459	0.221	-0.396
Arsenic	18	0.538	-0.381	0.166	0.082	-0.044	0.076	0.393	0.125	0.607	-0.592
Barium	18	-0.465	0.040	-0.189	-0.257	-0.169	-0.267	-0.244	-0.078	-0.339	0.391
Beryllium	18	0.371	-0.439	0.347	0.291	0.058	0.288	0.568	0.174	0.781***	-0.612
Cadmium	18	-0.392	0.327	-0.522	-0.624	-0.346	-0.633	-0.532	-0.261	-0.640	0.376
Calcium	18	-0.133	-0.028	-0.242	-0.042	0.092	-0.047	-0.205	0.235	-0.251	0.334
Chromium	18	-0.370	-0.079	-0.334	-0.376	-0.206	-0.374	-0.225	-0.225	-0.279	0.204
Cobalt	18	-0.211	-0.195	-0.119	-0.181	-0.217	-0.191	-0.014	-0.125	0.005	-0.037
Copper	18	-0.321	-0.143	-0.216	-0.369	-0.317	-0.369	-0.153	-0.254	-0.310	0.203
Iron	18	0.503	-0.188	0.159	0.258	0.119	0.259	0.337	0.324	0.507	-0.325
Lead	18	-0.413	0.066	-0.247	-0.289	-0.193	-0.290	-0.329	-0.141	-0.505	0.448
Magnesium	18	0.510	-0.277	0.145	0.240	0.120	0.243	0.394	0.247	0.543	-0.402
Manganese	18	-0.569	0.284	-0.506*	-0.304	0.013	-0.315	-0.560	-0.011	-0.582	0.654
Mercury	18	-0.380	-0.032	-0.281	-0.344	-0.138	-0.331	-0.304	-0.257	-0.289	0.181
Nickel	14	0.031	-0.174	0.057	-0.064	-0.343	-0.053	0.073	-0.279	0.199	-0.109
Potassium	13	0.525	-0.242	0.116	0.201	0.105	0.198	0.517*	0.123	0.717	-0.648
Selenium	18	-0.284	0.147	-0.351	-0.366	-0.243	-0.356	-0.297	-0.368	-0.510	0.274
Silver	18	-0.407	0.007	-0.404	-0.508*	-0.322	-0.517	-0.324	-0.235	-0.406	0.338
Sodium	18	0.534	-0.399	0.265	0.216	0.036	0.223	0.535	0.079	0.706	-0.674
Thallium	14	-0.423	0.332	-0.678*	-0.640*	-0.306	-0.647	-0.590	-0.245	-0.746	0.303
Vanadium	18	0.449	-0.257	0.297	0.384	0.154	0.384	0.435	0.326	0.706	-0.474
Zinc	14	0.176	0.044	-0.191	-0.246	-0.378	-0.233	-0.233	-0.080	-0.246	0.246
SEM-AVS ^a	13	0.000	0.044	0.314	0.295	0.246	0.281	0.055	0.428	-0.222	0.442
Miscellaneous											
Ammonia Nitrogen	18	-0.039	0.478	-0.201	-0.134	0.047	-0.136	-0.266	0.048	-0.288	0.286
Percent Fines	18	0.048	-0.035	-0.102	-0.017	0.042	-0.036	0.094	0.047	0.215	-0.134
pH	18	0.152	-0.283	-0.107	-0.234	-0.422	-0.221	0.116	-0.354	0.144	-0.499
TOC	18	-0.156	-0.082	0.047	0.121	0.154	-0.115	-0.012	0.261	-0.147	0.259
Salinity	18	-0.041	-0.373	0.074	0.092	0.051	0.081	0.142	0.058	0.307	-0.291

Notes:

Using a Bonferroni-adjusted alpha level based on the number of analytes (47), p must be ≤ 0.001 for a significant correlation to exist.

^a Stations with rejected Ni values were left out of the correlation analysis.

*** = p ≤ 0.001



Nonparametric Correlations Between Sediment Chemistry, Toxicity, and Benthic Invertebrate Community Metrics (cont.)

Analyte	N	Amphipod Survival	Number of Organisms	Number of Taxa	Shannon-Wiener H'	Pielou's Evenness J	Brillouin Diversity (H)	Virginian Province Biotic Index	Swartz's Dominance Index	Percent Crustacea	Percent Pollution-Tolerant Organisms
Organotins											
Dibutyltin	17	-0.154	0.206	-0.417	-0.322	-0.084	-0.303	-0.517	-0.025	-0.639	0.547
Monobutyltin	17	-0.561	0.068	-0.193	-0.061	-0.043	-0.084	-0.114	-0.213	-0.155	0.161
Tributyltin	17	-0.325	0.142	-0.470	-0.339	0.113	-0.325	-0.509	0.021	-0.495	0.460
PCBs/Pesticides											
Total DDT	18	-0.679	0.121	-0.185	-0.239	0.040	-0.216	-0.367	-0.327	-0.417	0.482
Total PCBs (homologue)	18	-0.389	0.236	-0.544	-0.564	-0.255	-0.582	-0.558	-0.084	-0.656	0.558
PCDD/Fs											
PCDD/F TEQ (Fish)	18	-0.381	0.179	-0.452	-0.539	-0.162	-0.519	-0.491	-0.442	-0.596	0.265
PAHs											
H-PAHs	18	-0.485	0.325	-0.300	-0.257	-0.034	-0.257	-0.398	-0.163	-0.615	-0.560
L-PAHs	18	-0.569	0.251	-0.241	-0.109	0.129	-0.114	-0.360	-0.038	-0.552	0.449
Total PAHs	18	-0.501	0.311	-0.280	-0.224	-0.001	-0.224	-0.383	-0.135	-0.601	0.397
Semivolatile Compounds											
1,4-Dichlorobenzene	18	0.001	-0.126	0.006	0.096	0.069	0.115	0.105	-0.121	0.034	0.015
2,4-Dichlorophenol	18	-0.028	-0.126	-0.042	0.091	0.151	0.092	0.057	0.011	0.032	0.065
Bis(2-ethylhexyl)phthalate	18	-0.379	0.280	-0.420	-0.397	-0.114	-0.398	-0.495	-0.004	-0.531	0.517
Butylbenzylphthalate	18	-0.033	-0.201	0.183	0.334	0.237	0.346	0.212	0.097	0.154	-0.029
Carbazole	18	-0.024	-0.241	0.044	0.118	0.087	0.124	0.147	-0.114	0.132	-0.064
Dibenzofuran	18	-0.049	-0.293	0.172	0.312	0.258	0.314	0.244	0.103	0.160	0.099
Dibenzothiophene	18	-0.437	0.224	-0.220	-0.162	0.024	-0.170	-0.303	-0.038	-0.545	0.384
Di-n-butylphthalate	18	0.014	-0.233	0.062	0.135	0.050	0.132	0.189	0.014	0.125	-0.038
Di-n-octylphthalate	18	-0.238	-0.045	-0.105	-0.027	0.056	-0.018	-0.105	-0.113	-0.296	0.274
N-Nitrosodiphenylamine	18	-0.002	-0.230	0.080	0.221	0.210	0.233	0.180	0.037	0.151	-0.028

Notes:

Using a Bonferroni-adjusted alpha level based on the number of analytes (47), p must be ≤ 0.001 for a significant correlation to exist.

^a Stations with rejected Ni values were left out of the correlation analysis.

*** = $p \leq 0.001$

Alternate (i.e., NOAA NS&T) Correlations Between Sediment Chemistry and Toxicity – Relaxed Assumptions of Statistical Significance

Analyte	N	Amphipod Survival	Analyte	N	Amphipod Survival			
Inorganic Chemicals								
Aluminum	18	0.347	Dibutyltin	17	-0.154			
Antimony	18	0.138	Monobutyltin	17	-0.561*			
Arsenic	18	0.538*	Tributyltin	17	-0.325			
Barium	18	-0.465						
Beryllium	18	0.371						
Cadmium	18	-0.392						
Calcium	18	-0.133						
Chromium	18	-0.370						
Cobalt	18	-0.211						
Copper	18	-0.321						
Iron	18	0.503*						
Lead	18	-0.413						
Magnesium	18	0.510*						
Manganese	18	-0.569*						
Mercury	18	-0.380						
Nickel	14	0.031						
Potassium	13	0.525						
Selenium	18	-0.284						
Silver	18	-0.407						
Sodium	18	0.534*						
Thallium	14	-0.423						
Vanadium	18	0.449						
Zinc	14	0.176						
SEM-AVS ^a	13	0.000						
Miscellaneous								
Ammonia Nitrogen	18	-0.039	1,4-Dichlorobenzene	18	0.001			
Percent Fines	18	0.048	2,4-Dichlorophenol	18	-0.028			
pH	18	0.152	Bis(2-ethylhexyl)phthalate	18	-0.379			
TOC	18	-0.156	Butylbenzylphthalate	18	-0.033			
Salinity	18	-0.041	Carbazole	18	-0.024			
Organotins								
Dibutyltin	17	-0.154	Dibenzo furan	18	-0.049			
Monobutyltin	17	-0.561*	Dibenzo thiophene	18	-0.437			
Tributyltin	17	-0.325	Di-n-butylphthalate	18	0.014			
PCBs/Pesticides								
Total DDT	18	-0.679**	Di-n-octylphthalate	18	-0.238			
Total PCBs (homologue)	18	-0.389	N-Nitrosodiphenylamine	18	-0.002			
PCDD/Fs								
PCDD/F TEQ (Fish)	18	-0.381						
PAHs								
H-PAHs sum 24			H-PAHs	18	-0.485*			
L-PAHs sum 24			L-PAHs	18	-0.569*			
Total PAHs sum 24			Total PAHs	18	-0.501*			
Semivolatile Compounds								
1,4-Dichlorobenzene	18	0.001						
2,4-Dichlorophenol	18	-0.028						
Bis(2-ethylhexyl)phthalate	18	-0.379						
Butylbenzylphthalate	18	-0.033						
Carbazole	18	-0.024						
Dibenzo furan	18	-0.049						
Dibenzo thiophene	18	-0.437						
Di-n-butylphthalate	18	0.014						
Di-n-octylphthalate	18	-0.238						
N-Nitrosodiphenylamine	18	-0.002						

Notes:

Using a Bonferroni-adjusted alpha level based on the number of analytes (47), p must be ≤ 0.001 for a significant correlation to exist.

^a Stations with rejected Ni values were left out of the correlation analysis.

* = $p \leq 0.05$

** = $p \leq 0.01$

Spearman Rank Correlations of Sediment Quality Guidelines and Toxicity and Benthic Invertebrate Community Parameters (n=18)

	Amphipod Survival	Number of Individuals	Number of Taxa	Shannon-Wiener Diversity Index	Pielou's Evenness (J)	Brillouin's H	Swartz Dominance Index	Virginian Province IBI	Percent Crustacea	Percent Pollution Tolerant Organisms
ER-MQ (PAH categories)	-0.553	0.235	-0.374	-0.322	0.082	-0.316	-0.047	-0.618**	-0.719**	0.677**
ER-MQ (PAH individual)	-0.491	0.239	-0.311	-0.269	0.088	-0.263	-0.061	-0.533	-0.702**	0.553
SQGQ ER-M + Mn	-0.565	0.275	-0.406	-0.361	0.060	-0.355	-0.080	-0.649**	-0.756**	0.694**
SQGQ ER-M + BEP	-0.523	0.282	-0.372	-0.341	0.011	-0.334	-0.061	-0.632**	-0.697**	0.635**
SQGQ ER-M + PCDD/F TEQ	-0.544	0.261	-0.384	-0.350	0.024	-0.345	-0.065	-0.645**	-0.726**	0.663**
SQGQ All benchmarks	-0.497	0.236	-0.368	-0.328	0.031	-0.321	-0.037	-0.614**	-0.696**	0.622**

Notes:

Using a Bonferroni adjusted alpha level based on the number of analytes (6), p must be ≤ 0.01 for a significant correlation to exist.

** = $p \leq 0.01$

Concordance of Triad Components

Station	Sediment Type	Sediment Toxicity	BIC Condition	Component Agreement
13	3	Highly toxic	Good - Excellent	No
1	3	Highly toxic	Poor	Yes
2	3	Highly toxic	Poor - Good	Yes
3	2	Nontoxic	Good	Yes
4	3	Nontoxic	Poor - Good	No
14	3	Highly toxic	Poor	Yes
5	3	Nontoxic	Good	No
6	3	Marginally toxic	Good	No
7	3	Marginally toxic	Poor - Good	No
8	3	Highly toxic	Good	No
15	3	Highly toxic	Poor	Yes
9	4	Highly toxic	Poor - Good	Yes
10	3	Marginally toxic	Poor	Yes
11	4	Nontoxic	Poor	No
12	3	Highly toxic	Poor	Yes

Note:

Stations ordered from downstream to upstream in PRSA.

SQT Uncertainties

- Unidentified/unanalyzed chemicals could be impacting sediment toxicity and benthic invertebrate community structure
- Seasonal effects on sediment toxicity, sediment chemistry, and benthic invertebrate community structure and composition
- Role of chemical synergy in sediment toxicity and benthic invertebrate community structuring
- No SQGs available for many detected chemicals

Overall Weight-of-Evidence Conclusions

- Elevated levels of chemicals found at many PRSA stations relative to Reference Area
- No clear spatial gradients in chemical concentrations present in the PRSA
- Sediment quality guidelines exceeded for a number of chemicals at multiple stations
- Amphipod toxicity detected in PRSA samples – no clear spatial gradient
- Amphipod toxicity not likely caused by single chemical or physical factor
- PRSA benthic invertebrate community structure and composition generally “poor” relative to the Reference Area

Next Steps

- Multi-variate statistical analyses
- Evaluate SQT with respect to TIE results